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Water erosion prediction for soils in the Peace River region of B.C. : estimates using the universal soil loss equation

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Water erosion prediction for soils in the Peace River Region of British Columbia:

Estimates using the universal soil loss equation

Canada

Water erosion prediction for soils in the Peace River Region of British Columbia:

Estimates using the universal soil loss equation

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SUMMARY

A lack of information on the location, magnitude, extent, and distribution of soil erosion by water has hindered the development of effective soil conservation planning for controlling erosion on agricultural land in British Columbia's Peace River region. With more attention focused recently on water erosion in the Peace River region and an increased awareness and local interest in soil conservation, it became apparent that an assessment of soil erosion for this agricultural region would be both timely and useful.

This report describes the water erosion process and the universal soil loss equation (USLE) to soil map polygons for six map sheets (scale 1:100 000) in the B.C. Peace River region. The erosion prediction maps, included in the plastic pocket with the report, contain information on appropriate soil conservation measures for controlling water erosion. The relative inherent erodibility of the major soils in the region is presented. The mapping process is outlined, and limitations of the erosion prediction maps are described. Assessment of the magnitude and extent of soil erosion for the region is discussed based on data summaries in tables and figures for individual USLE factor values (*C*, *K*, *L*, and *S*) and for individual map sheets, in terms of areal distribution of total annual soil loss. Soil conservation practices for controlling water erosion are proposed and discussed. During discussion of the results, it is demonstrated how two user groups, the primary producers and regional planners, could benefit from the information contained in the report and on the maps.

Results of areal distribution by class of land use (*C* value), soil erodibility (*K* value), slope length (*L* value), and slope steepness (*S* value) are presented for each map sheet and for the Peace River region of British Columbia. The Dawson Creek (93P/NE) and Fort St. John (94A/SE) map sheets, with the highest percentage of cropland at 35 and 44%, respectively, stand out as representing the most developed agricultural areas in the region, compared with 18% in cropland for the region (the six map sheets combined). The relative, inherent erodibility of the major soils in the region have been determined, and results indicate that 63% of Peace River soils are moderately erodible (*K* values between 0.21 and 0.40). Slopes exceeding 1200 m in length (slope classes 5 and 6) occur most extensively on five of the six map sheets. The crude method used in estimating slope length has resulted in a likely overestimation. Areal distribution data of slope steepness classes show that slopes between 6 and 15% are the most extensive, occupying between 51 and 72% of each map sheet area and 49% of the region.

RÉSUMÉ

Le manque de données sur l'emplacement, l'importance, l'étendue et la répartition de l'érosion hydrique des sols a entravé la mise au point de méthodes efficaces de planification de leur conservation dont le but est de lutter contre l'érosion des terres agricoles. Compte tenu de l'importance grandissante accordée récemment à l'érosion hydrique dans la région de Rivière-de-la-Paix en Colombie-Britannique depuis quelques années, ainsi que

de la sensibilisation accrue du public et du plus grand intérêt local manifesté pour la conservation des sols, il a semblé qu'une évaluation de l'érosion des sols de cette région serait à la fois opportune et utile.

Le présent rapport décrit l'érosion hydrique et l'application de l'équation universelle des pertes en terre (EUPS) à des polygones de cartes pédologiques pour six feuilles de carte (échelle de 1:100 000) dans la région de Rivière-de-la-Paix. Les cartes de prédiction de l'érosion, incluses dans la pochette en plastique avec le rapport, contiennent des données sur des mesures pertinentes de conservation du sol pour lutter contre l'érosion hydrique. L'auteur présente l'érodibilité inhérente relative des principaux sols de la région.

Il explique la méthode utilisée pour dresser les cartes et décrit les limites des cartes de prédiction de l'érosion. L'auteur traite aussi de l'évaluation de l'importance et de l'extension de l'érosion des sols pour la région en se fondant sur les résumés de données présentées dans les tableaux et les figures pour chaque valeur des facteurs USLE (*C*, *K*, *L* et *S*) et pour chaque carte indiquant la répartition de la perte totale annuelle de sols dans une aire donnée. Les pratiques de conservation des sols en vue d'éviter l'érosion hydrique sont exposées et traitées. Dans l'exposé des résultats, on montre comment deux groupes d'usagers, les producteurs primaires et les planificateurs régionaux, peuvent mettre à profit l'information qu'on peut trouver dans le rapport et sur les cartes.

Pour chaque carte et pour toute la région de Rivière-de-la-Paix (C.-B.), on présente les résultats de la distribution des aires par classe d'utilisation des terres (valeur *C*), l'érodibilité des sols (valeur *K*), la longueur des pentes (valeur L) et l'inclinaison des pentes (valeur *S*). Les cartes de Dawson Creek (93P/NE) et Fort St. John (94A/SE), régions qui possèdent les pourcentages les plus élevés de terres arables, soit 35% et 44% respectivement, montrent quelles sont les aires de culture les plus développées dans cette région, si on compare avec l'ensemble de la région dont le pourcentage de terres arables n'est que de 18% (total des six cartes). L'érodibilité relative et inhérente de la plupart des sols de la région a été évaluée et les résultats ont montré que 63% des sols de Rivière-de-la-Paix ont une érodibilité moyenne (les valeurs K varient de 0,21 à 0,40). Les pentes dont la longueur est supérieure à 1200 m (classes 5 et 6) ont une grande fréquence sur cinq des six cartes. Il semble qu'en utilisant la méthode rudimentaire pour l'évaluation de la longueur des pentes qu'on soit arrivé à une surévaluation. Les données de la distribution des aires des classes de l'inclinaison des pentes montre que les pentes entre 6 et 15% sont les plus répandues et occupent entre 51 et 72% de chaque carte et 49% de la région.

INTRODUCTION

Soil erosion, as a major cause of land degradation, has become a problem that affects the production capabilities of the land. Soil erosion commonly results in a net loss of irreplaceable soil, with constituents being washed away that are needed for optimum crop production. Concern over soil erosion is worldwide (Larson et al. 1983; Brown and Wolf 1984).

In western Canada, the seriousness of soil erosion by water in the Peace River region has been recognized since the early part of this century. Albright (1939) reported that the menace of water erosion in the Peace River region was imminent and great. He concluded that "if it is not studied, some fine farming country will head for ruin, production will decline, operating costs will rise and there will be washed-out farmers to rehabilitate in the next generation."

Since these early observations, many more researchers have documented qualitatively the seriousness of water erosion in the Peace River region, not only regarding sheet and rill erosion, but also for gully erosion (Rowles 1948; Laird 1950; Chapman et al. 1952; Johnson 1961; Farstad et al. 1965). Novak and van Vliet (1983) identified the Peace River region as being at greatest risk from erosion among agricultural regions in British Columbia. Thus in recent years investigators of agricultural soil erosion in British Columbia have concentrated on the Peace River region (van Vliet 1979; Klein 1980; van Vliet et al. 1986). In Alberta, an assessment of soils for potential erosion by water, including the Peace River region, was published by Tajek et al. (1985) with a map of erosion potential at 1:1 000 000.

A lack of information on soil erosion by water has hindered the planning of effective soil conservation for controlling erosion on agricultural land. Recently, more attention has been focused on erosion by water in British Columbia's Peace River region and awareness of, and local interest in, soil conservation has increased. Thus an assessment of soil erosion for this agricultural region is now both timely and useful for primary producers and for regional soil conservation planners.

The objectives of this study were as follows:

- to estimate the relative inherent erodibility of the major soils in the B.C. Peace River region;
- to compile maps at a scale of 1:100 000 for the region showing location and distribution of predicted soil loss from water erosion;
- to assess the magnitude and extent of soil erosion in the region; and
- to suggest appropriate soil conservation measures for controlling water erosion.

SOIL EROSION BY WATER

Soil erosion by water is a naturally occurring process that can be greatly accelerated by the activities of people. The three-step process involves detachment, transport, and deposition. During the first step, small soil particles or aggregates become detached from the soil surface either by the impact of raindrops or, when the rate of rainfall exceeds that of infiltration, by the shear force of running water. The occurrence of detachment depends on the ability of particles to resist the erosive forces. Well-aggregated, humus-rich, and finer-textured soils are generally more resistant to detachment than very fine sandy or silty soils with weak structure.

During the second step in the erosion process, detached soil particles are transported, resulting in actual soil loss. Transportation is primarily by runoff and, to a lesser degree, by raindrop splash. Runoff occurs only when the amount of water, from rainfall or snowmelt, exceeds the soil infiltration rate. The amount of soil transported is influenced by the size, density, and shape of the individual soil particles and aggregates, and also by the retarding effect of vegetation and surface roughness. Bare soil surfaces, exposed when runoff occurs, are especially vulnerable to erosion. As most storms in the Peace River region occur during July and August, crops in cultivated fields provide good protection to the soil surface, substantially reducing erosion risk when compared with fallowed land.

Deposition is the third step in the erosion process. Eroded soil particles come to rest when forces of resistance are greater than those of erosion. Deposition may be caused either by a change in vegetation or type of crop (for example, from row crop to pasture), by less steep slopes, or by a field boundary such as a fence or hedge row. Deposition of soil in places where it is not wanted is another negative effect of erosion. Crops and pastures may be damaged by soil deposited on them by runoff. Ditches and stream channels may be clogged and reservoirs reduced in capacity by the deposition of sediment. Pollution by sediment is a major factor causing impaired water quality in our streams and lakes.

Different kinds or expressions of soil erosion by water are recognized in the landscape. They include both general (sheet and rill) erosion and more site-specific gully erosion. Soil movement resulting from raindrop splash and surface runoff is called sheet erosion. Because sheet erosion occurs rather uniformly over the slope, it may go unnoticed until most of the productive topsoil has been removed. As runoff collects and flows downslope via micro-surface depressions, the water may remove soil to form small but well-defined channels. Channels that do not seriously interfere with normal tillage operations are called rills. Both sheet and rill erosion are the least apparent but most damaging forms of erosion as they cause gradual thinning of the soil profile over entire slopes. Gullies, the most dramatic expression of water erosion, are caused by further channeling of runoff into larger rills, eroding until they cannot be smoothed over by normal tillage practices.

Both rainfall and runoff must be considered in assessing erosion by water, as well as the inherent characteristics of the soil itself. Slope steepness and slope length are also important factors controlling erosion, mainly because of their effect on the generation of overland flow. As slopes become steeper, the speed or energy of runoff increases, thereby enhancing its ability to detach soil particles from the soil mass. A longer slope contributes to greater accumulations of runoff, often resulting in concentrated flow in well-defined rills or channels, leading to gully erosion. Vegetation or land use is important in protecting the soil surface from the direct impact of raindrops and in reducing runoff. For example, dense forest or grass cover reduces soil loss to near zero even on steep slopes. Cultivation or other practices that deprive soil of protective vegetation cover or decrease soil aggregate stability increase soil erosion. The use of farming practices such as monoculture, nonforage rotations, fallowing, up-and-down-slope cultivation, intensive fall cultivation rather than just spring cultivation, and excessive field lengths may all increase the risk of erosion.

For a given location (site or field), the rate of erosion is determined by the combined effect of all the physical, climatic, and management conditions. To develop appropriate soil conservation measures for controlling erosion by water, it is not enough just to quantify the erosion rate at a location. It is also necessary to evaluate the effect of each variable and to identify specific causes of erosion. Mathematical models can then be used to partition the erosion process into components and to enable the prediction of soil losses resulting from specific site conditions. Among several emperical erosion models available, the most widely used predictive model is the universal soil loss equation developed by Wischmeier and Smith (1978).

UNIVERSAL SOIL LOSS EQUATION

The universal soil loss equation (USLE) is an empirical model of soil erosion designed to predict a long-term average of soil loss for a specific location in the landscape or field area in a specific cropping management system. Long-term climate and cropping management data are used to average out the random short-term variations in influential variables. For other variables, single or average values from point measurements are used in the equation. The basic equation is expressed as the combined effect of six influential factors:

$$A = R \cdot K \cdot LS \cdot C \cdot P^{*}$$

Average annual predicted soil loss (A) is expressed in terms of rainfall

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* The units used for soil loss calculations are English units: A = t/acre; R = inches; L = feet; S = %, K, C, and P = dimensionless. Values of A were subsequently converted to SI (metric) units: A = t/ha/year for data presentation.

intensity (*R*), the inherent erodibility of the soil (*K*), topography (*LS*), consisting of length of slope, *L*, and steepness of slope, *S*, cover or cropping management practice (*C*), and erosion control or conservation practices (*P*). The calculated soil loss includes both sheet and rill erosion caused by raindrop impact and surface runoff. However, gully erosion, mass wasting, or deposition of sediments cannot be predicted by the USLE. Because some variables fluctuate unpredictably over a short time, particularly rainfall, the use of the USLE for prediction of soil loss during specific events or in specific years is not recommended (Wischmeier 1976).

To accomplish the objectives of this study, some factors of the USLE had to be modified to reflect specific climatic and topographic conditions in the B.C. Peace River region. The rainfall factor (*R*) was modified to account for snowmelt runoff in addition to rainfall. A slope effect (*LS*) chart that includes very long slopes was used for determining the topographic factor. These modifications are discussed in detail later on.

After these modifications, the USLE was calibrated for the B.C. Peace River region, using measurements from 5 years of soil erosion on controlled plots at Beaverlodge Research Station. Values for long-term predicted soil loss calculated for these plots using the USLE were found to be higher than the values for 5-year mean measured soil loss, as follows: for continuous cropping, 4 versus 1 t/ha; for grass, 1 versus 1 t/ha; and for continuous fallowing, 17 versus 11 t/ha (van Vliet et al. 1986). In addition, preliminary analyses of 6 years of erosion plot data at other locations (Dawson Creek and Fort St. John) generally confirm the higher, USLE predicted soil loss versus measured soil loss values. There are, however, limitations in comparing long-term predicted soil loss with relatively short-term measured values on small erosion plots. Investigations are now in progress across Canada to determine what factors in the USLE are responsible for overpredicting soil loss, with the aim of modifying the equation and producing a handbook for the application of the USLE in Canada.

Despite the limitations of the USLE in accurately predicting site-specific soil loss, it is felt that the relative values for soil loss presented throughout this report are valid and that the application of the USLE should provide a reasonable assessment of soil erosion by water for the Peace River region of British Columbia.

RAINFALL AND RUNOFF FACTOR

The rainfall and runoff factor (*R*) quantifies the long-term average annual erosive effect of raindrops and surface runoff caused by rain. However, for the Peace River region, the use of a rainfall factor alone could underestimate annual soil losses, because long-term average annual snowfall accumulations are about 190 cm, contributing to about 40% of the annual precipitation (Atmospheric Environment Service 1982). Farstad et al. (1965), Chanasyk and Woytowich (1983), and van Vliet et al. (1986) pointed out that much of the annual surface runoff was related to snowmelt and that snowmelt runoff could cause significant erosion. When the soil is frozen, a thin, thawed surface layer becomes quickly saturated during periods of snowmelt,

resulting in erosion as soon as the soil is exposed. Repeated thawing and freezing and puddling of the saturated layer causes the breakdown of natural soil aggregates, making the soil more erodible and thus increasing soil losses. Therefore, snowmelt must be considered in any assessment of water erosion in the Peace River region. The total amount of snowfall precipitation during the winter months will eventually contribute to runoff upon thawing, which may take place at any time during the winter under the influence of the Chinook winds, and during the period of spring snowmelt.

The combined contribution of rainfall and snowmelt to total soil loss was estimated by McCool et al. (1976) in a total precipitation factor, R_t, for the assessment of soil loss in the Pacific Northwest region as follows:

$$R_t = R + R_s$$

where R_t = rainfall and runoff erosion factor (also called total precipitation factor)
R = rainfall component (measured erosion index or EI value for spring, summer, and fall)
R_s = snowmelt component (equivalent erosion index for winter months)

To determine R_t, McCool et al. (1976) used the following formula:

$$R_t = 27\ P^{2.2*} + 1.5\ P_{(D-M)}$$

where R_t = rainfall and runoff erosion factor
P = 2-year return interval, 6-h duration precipitation in inches
$P_{(D-M)}$ = December through March precipitation in inches.

Rainfall intensity data for five climate stations in the B.C. Peace River region were provided by the Atmospheric Environment Service (1983) in Vancouver. Complete and reliable data for four stations were used for the calculations of R values (Table 1). R_s values were calculated from long-term precipitation data during the winter months (December through March). Since the period of record for individual stations ranged from 7 to 11 years, and only four stations were used for calculating the precipitation factor R_t, an isoerodent map for the B.C. Peace River region could not be reliably produced. Consequently, a mean R_t value of 34 was used for the erosion assessment by the USLE for the Peace River region based only on these four stations. This average value falls between the R_t values for Dawson Creek Airport and Fort St. John Airport climate stations (Table 1), which are located fairly centrally for much of the agricultural land in the B.C. Peace River region. R_t values for locations north (Fort Nelson) and east of the B.C. Peace River region are lower than the average value of 34 for stations within the agricultural region (Table 1). Because the low density in the network of climate stations, the influence of factors such as local variation in topography, elevation, and proximity to the Rocky Mountains are not expressed in the R_t value. Note that the average R_t value of 34 represents the combined erosivity of rainfall and snowmelt runoff over a broad geographic area.

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* $27\ P^{2.2}$ is the rounded off version of the modified Wischmeier (1974) rainfall and runoff factor for the western states, which was also derived independently by Ateshian (1974).

Table 1 Precipitation factor (R_t) for selected stations in, and adjacent to, the B.C. Peace River region

Station	Years of Record	R (Rainfall)	R_s (Snow)	R_t (Total)
		(as erosion index units)		
B.C. PEACE RIVER REGION				
Chetwynd	11	15.7	7.7	23.4
Dawson Creek Airport	10	29.4	7.0	36.4
Fort St. John Airport	7	25.4	7.2	32.6
Hudson Hope	10	35.9	8.5	44.4
Mean R_t value used for soil loss prediction				34
ADJACENT TO B.C. PEACE RIVER REGION				
Fort Nelson Airport	15	21.3	5.3	26.6
Beaverlodge, Al.	20	21.3	6.9	28.2
Grande Prairie, Al.	14	15.7	6.5	22.2
Peace River, Al.	16	18.9	4.8	23.7

SOIL ERODIBILITY FACTOR

The soil erodibility factor (K) expresses the inherent susceptibility of soil to detachment and transportation by raindrop impact and runoff. K values were experimentally determined for many soils in the United States using standard plots in many parts of the country. To assign K values for individual soils, Wischmeier et al. (1971) constructed a soil erodibility nomograph (Fig. 1). In this simple nomograph, the numerical value for any given soil is expressed as a function of the following soil parameters: % silt + very fine sand (0.10-0.002 mm), % sand (0.10-2.0 mm), % organic matter, type of soil structure, and soil permeability. With the exception of permeability, all the soil parameters are determined for the top 20 cm of the soil.

K factor values were obtained for the soils recognized in the Peace River region of B.C. using information from soil descriptions and analytical data for one or more profiles from each soil (van Vliet 1983). When data on particle size were not available, the midpoint value of the textural class or classes indicated in the profile description was used. Occasionally, the % organic matter was not known and was assumed to be 2%, the midpoint value of the range (0-4%) listed in the nomograph. When the top 20 cm of a soil consisted of more than one horizon, K values were determined separately by

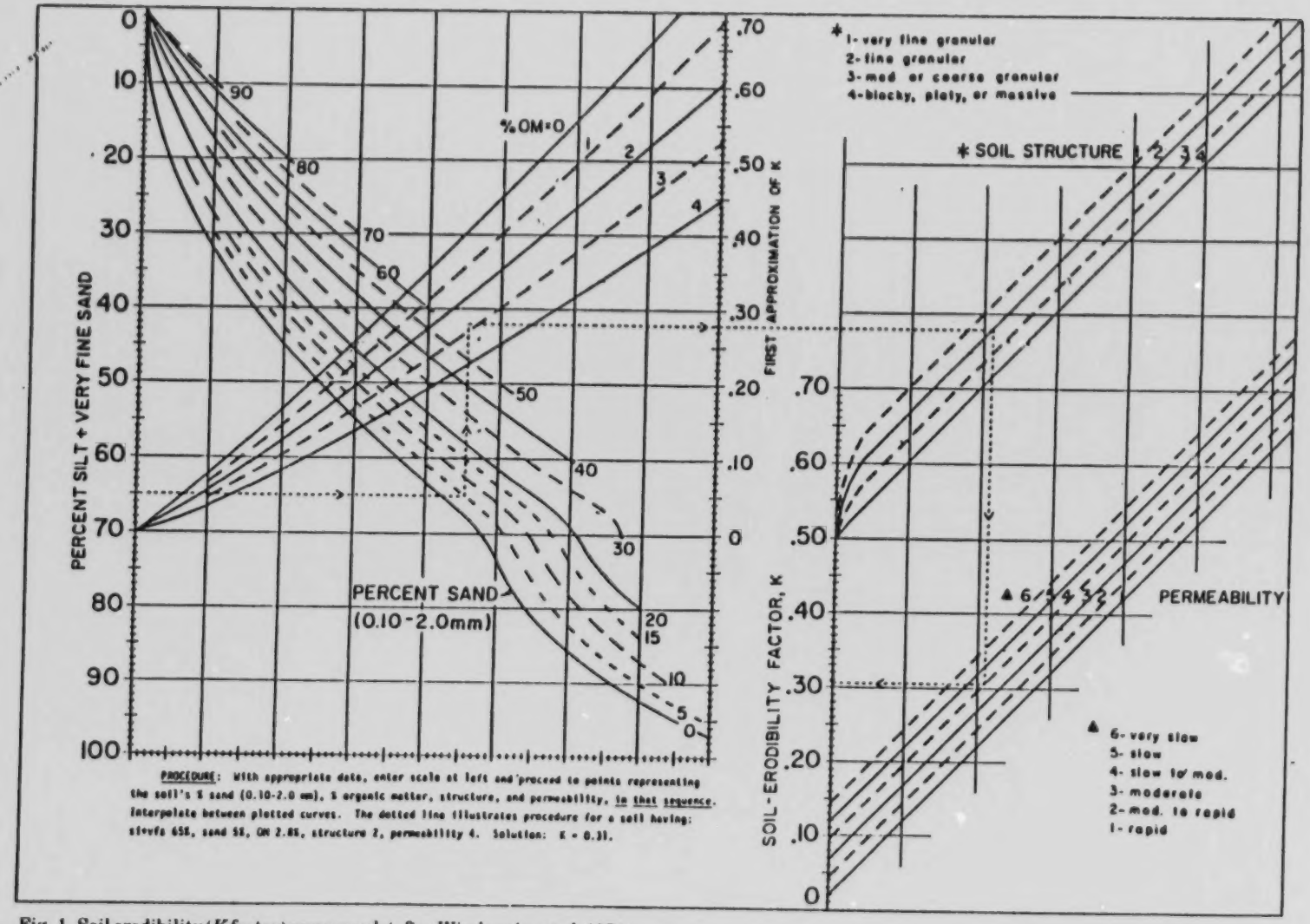

Fig. 1 Soil erodibility (*K* factor) nomograph (after Wischmeier et al. 1971).

horizon, then a depth-weighted mean *K* value was calculated. As most Peace River soils are low in coarse fragments, no adjustments in *K* values were made for coarse fragment content.

The computed *K* factor values for the soils and specific for the surface texture, are listed in Appendix 1. Note that these *K* values are underestimations for three reasons. First, for most of the soils, data for the very fine sand fraction was not available. Second, during the original soil survey, most soils were sampled at noncultivated (virgin) sites, which may have a higher percentage of organic matter than cultivated soils. Third, no adjustments for seasonal variation were made; these are usually seen as higher *K* values during the spring thaw period.

Despite some of these limitations, the *K* values thus obtained should rank the relative erodibility of individual soils in the region.

Mean *K* values by surface textures for B.C. Peace River soils are summarized in Table 2. They range from 0.09 for loamy sand textured soils to 0.42 and 0.47 for silt loam and very fine sandy loam textured soils, which are deeply leached and have poorly structured surface horizons. This wide range in *K* values reflects the variation in texture and pedogenic development of soils in the B.C. Peace River region. When the *K* values for the soils in Appendix 1 are grouped into six erodibility classes, the percent distribution in Fig. 2 indicates that most (63%) Peace River soils have medium *K* values ($0.21 < K < 0.40$), whereas 14% of the soils fall within the highly erodible group ($K > 0.41$).

Table 2 Mean soil erodibility (*K*) values summarized by surface texture for B.C. Peace River soils

Surface texture	Mean *K* value	Range in *K* values	Number of soils
Very fine sandy loams	0.47	0.35 - 0.59	2
Silt loams	0.42	0.27 - 0.62	24
Silty clay loams	0.28	0.22 - 0.36	18
Loams	0.27	0.13 - 0.36	16
Silty clays	0.27	0.27	1
Clay loams	0.23	0.14 - 0.33	6
Sandy clay loams	0.23	0.18 - 0.28	2
Fine sandy loams	0.21	0.13 - 0.40	7
Sandy loam	0.18	0.09 - 0.29	7
Clays	0.15	0.14 - 0.15	3
Loamy sands	0.09	0.06 - 0.12	3

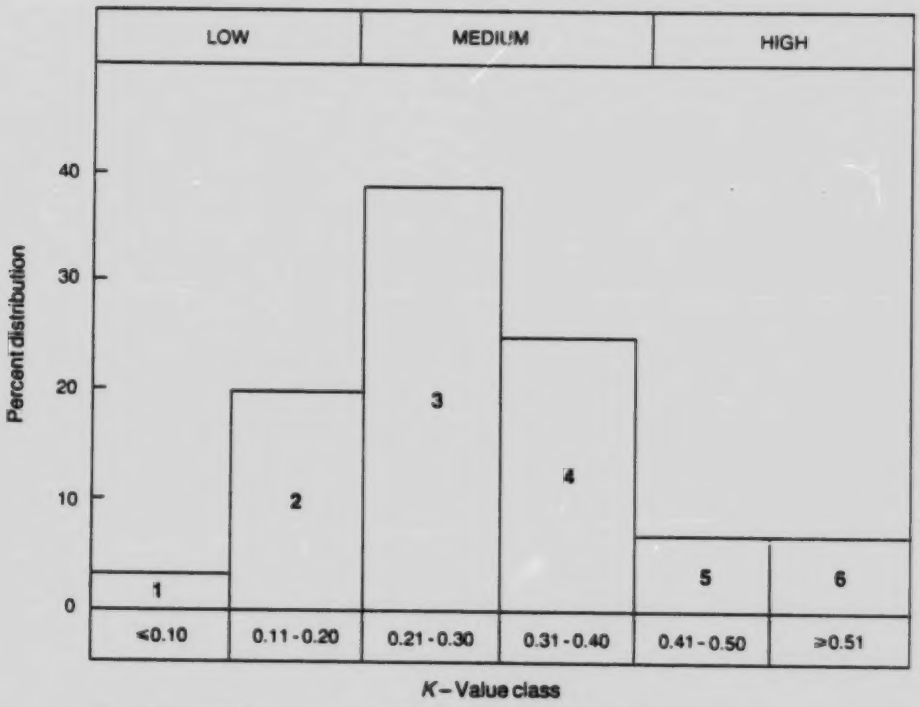

Fig. 2 Percent distribution of soils grouped in erodibility classes.

TOPOGRAPHIC FACTOR

The topographic factor (*LS*) reflects the combined effects of length (*L*) and steepness (*S*) of the land slope on soil loss. Slope length is defined as the distance from the point of origin of overland flow to the point at which either the steepness of the slope decreases enough that deposition begins, or the runoff enters a well-defined channel that may be part of a drainage network. Numerically *LS* is the expected ratio of soil loss per unit area to that from the standard "Wischmeier" plot (22 m long on a uniform 9% slope). On simple slopes, the *LS* value for specified slope length and uniform steepness could be obtained directly from the *LS* chart (Wischmeier and Smith 1978).

In the Peace River region, many of the cropland slopes are longer than the range of slope length for which the USLE was originally developed (9-90 m). This problem was also encountered in the Palouse area of the Pacific Northwest, where, based on limited soil erosion observations, a modified *LS* chart has been developed (U.S. Department of Agriculture 1974). This latter chart was used in this study to obtain *LS* values for Peace River topography (Fig. 3). The accuracy of the relationship beyond the original ranges in slope length and slope steepness has not been determined by direct measurements but appears to be acceptable.

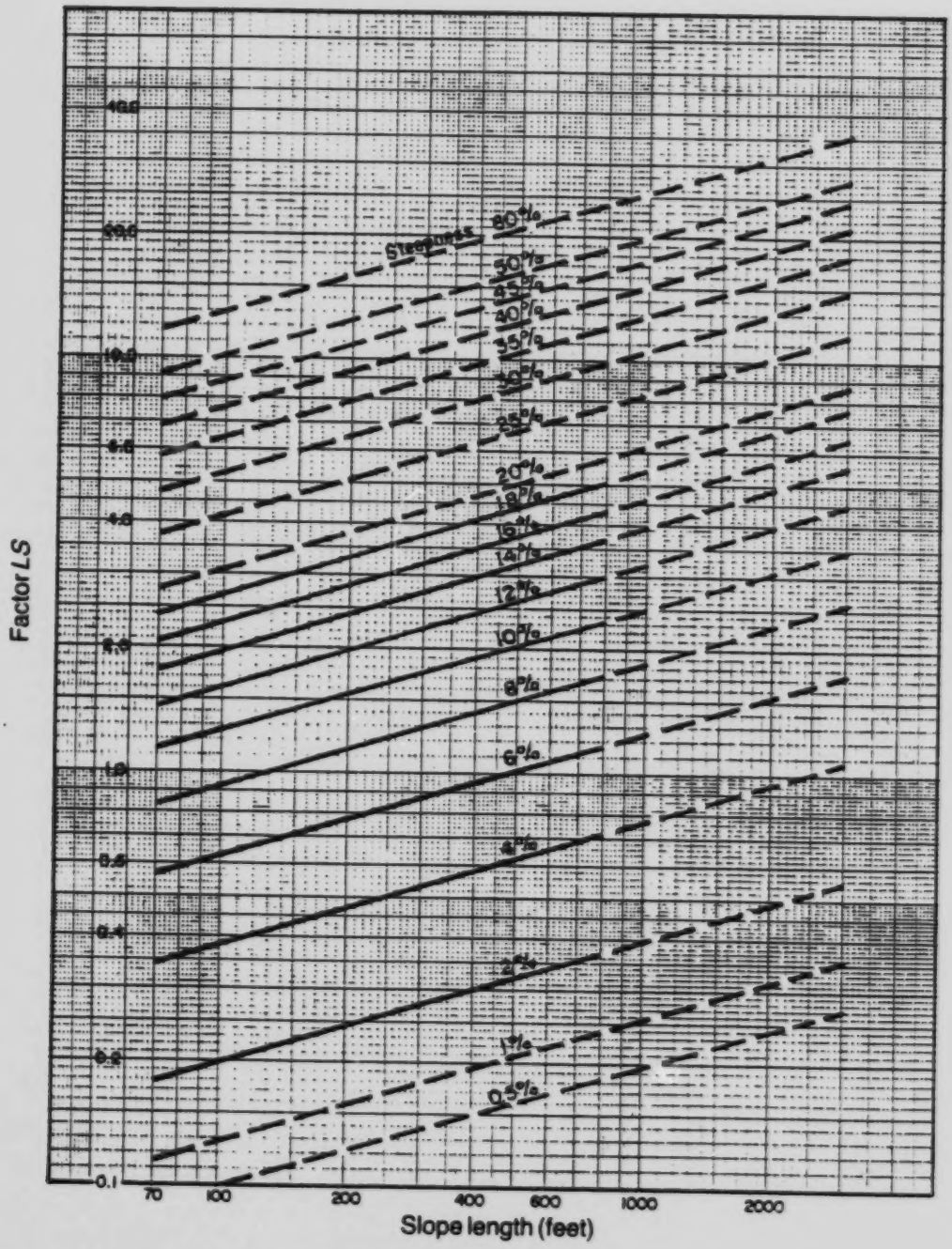

Fig. 3 Slope effect chart for assessment of topographic factor (*LS*) values (after U.S. Department of Agriculture 1974).

The *LS* values from the graph predict average soil loss ratios over an entire slope. A change in land cover or a substantial change in steepness along a slope does not define the beginning of a new slope length for purposes of soil loss estimation using the USLE. Under field conditions, the rate of soil loss will change with distance from the top as well as with the shape of the slope. However, slope configuration was not considered in the erosion assessment for the B.C. Peace River region.

COVER AND MANAGEMENT FACTOR

The cover and management factor (*C*) in the USLE represents the ratio of soil loss for cropped land under known cropping or cover conditions to the corresponding soil loss from continuously tilled or fallow land for the same soil, slope, and rainfall intensity. Cover and management effects must be evaluated together because many interrelationships are significant. For example, the kind of crop, whether it is grown continuously, or in rotation with other crops or involving summer fallow, length of rotation, and time of tillage and seeding, strongly influence the kind and amount of cover and its distribution over the year. Also, the kind of tillage affects the amount of residue, which is a cover consideration. The canopy protection of crops not only depends on the type of vegetation, the stand, and the quality of growth, but it also varies greatly in different months or seasons. These considerations must in turn be integrated with the seasonal distribution of the precipitation factor. A high R_t value may not be too serious if it occurs at a time when plant cover is good, but if it coincides with a period of bare soil or the emergence of a crop just seeded, high soil losses may result. The interdependence of these many components gives the *C* factor a strong geographical orientation. In addition, the *C* factor is very location-specific in terms of broad land use categories that do not change from year to year, such as cropland, permanent pasture, and woodland. Specific crops, however may change from year to year at any location, but because the USLE is predicting long-term average annual soil losses, the *C* value should reflect the average annual cropping and management conditions for the entire crop rotation.

The *C* factor values determined for the B.C. Peace River region (Table 3) are based on common agricultural practices and crop rotations, average time sequence of various operations, and annual distribution of the R_t factor. The procedures outlined by Wischmeier and Smith (1978) were followed. For all annually cultivated cropland in the B.C. Peace River region, a *C* factor value of 0.30 was used, basically reflecting the two major crops grown: cereal and oil seed crops. Both crops are often grown in rotation and commonly include a forage or grass seed crop. Also, preliminary results of erosion plot monitoring in the region have indicated similar in soil loss from cereal and oil seed crops (van Vliet et al. 1986).

Table 3 Cover and management factor (*C*) values for generalized land use categories for the B.C. Peace River region

Land use cartegory	*C* value
Annually cultivated cropland	0.30
Permanent pasture (includes open grassland and grazing land)	0.05
Unproductive land (includes badlands, eroded river banks)	0.03
Woodland (includes all forest land and peat land)	0.02

SUPPORT PRACTICE FACTOR

The support practice factor (*P*) in the USLE is the ratio of soil loss with a specific support practice to the corresponding loss with up and down slope cultivation. The *P* factor includes conservation practices that slow the runoff and thus reduce the amount of soil particles it can carry. These include cross-slope and contour tillage, strip cropping on the contour, and terracing. Stabilized waterways for the disposal of excess runoff are a necessary part of each of these practices. The *P* factor reflects the effects of these practices on the reduction of soil loss.

Improved tillage practices, sod-based rotations, fertility treatments, or greater quantities of crop residues left on the field also contribute to soil erosion control. However, these are considered as cropping practices, and the benefits derived from them are included in the *C* factor.

The *P* factor was not used in the computation of soil loss because these conservation practices, with the exception of cross-slope tillage, are seldom used in the B.C. Peace River region at the present time. Although a considerable amount of some form of cross-slope tillage is practiced (e.g., diagonal to the slope), its effect on soil loss prediction is unknown. Consequently, the *P* factor value in USLE soil loss calculations assumes a value of 1.

WATER EROSION PREDICTION MAPS

MAPPING PROCESS

Prediction information on water erosion was compiled for six 1:100 000 scale maps (Table 4), covering the whole study area. Four of the six map

sheets listed in Table 4 cover the area of both the originally published soil survey (Farstad et al. 1965) and the recently published more detailed soil survey (Lord and Green 1986). In light of land-clearing activities in the late 1970s and early 1980s taking place north of the existing published soil survey report area, the Rose Prairie (94A/NE) and Blueberry River (94A/NW) soil map sheets (Lord 1974) were added to this erosion prediction project, which then comprised a total area of 2 068 260 ha.

Table 4 Area, number of polygons, and average polygon size by map sheet of water erosion prediction maps for the B.C. Peace River region

Map sheet Number	Name	Area (ha)	Number of polygons	Average polygon size (ha)
93P/NE	Dawson Creek	336 682	781	431
93P/NW	Moberly Lake	347 732	696	500
94A/SE	Fort St. John	337 891	803	421
94A/SW	Hudson Hope	343 615	654	525
94A/NE	Rose Prairie	348 600	557	626
94A/NW	Blueberry River	353 740	488	725
For the B.C. Peace River region		2 068 260	3979	520

Several sources of information were used to obtain USLE erosion prediction values for each map delineation or polygon (area on the map enclosed by lines).

First, soil manuscript maps for the area originally produced for Canada Land Inventory (CLI) capability analyses, at a scale of 1:50 000* were reduced to a scale of 1:100 000. At the start of the project in 1980 these data were the most updated and recent soils information available. Based on the soil symbol on the map, which identifies the soil name or names for the polygon, the appropriate values for the soil erodibility factor (*K*) from Appendix 1 were recorded in each polygon on copies of the soil maps. For polygons with more than one soil name, area weighted average *K* values were recorded. Variability in *K* values caused by variation in one or more soil properties may occur for different polygons with the same symbol. Consequently, inaccuracies may have been introduced when extrapolating *K* values, which are based on point data of one soil, to all polygons with the same symbol. *K* values for organic soils were assumed at 0.05.

* Available from Maps B.C., Ministry of Environment, Victoria, B.C.

Second, the value for the slope steepness factor (*S*) was recorded for each polygon as the midpoint value of the range in percent slope represented by the slope class or classes listed in the polygon symbol on the soil maps. This method assumes that slope values within the polygon are normally distributed. The base maps for the soil manuscript maps were topographic maps with contour intervals of 50 ft (15 m). They were used to measure the values for the slope length factor (*L*) as the length in metres perpendicular to the dominant slope direction starting upslope at the polygon boundary to either an expected point where deposition begins within the polygon (as defined under "Topographic factor"), or if no point of deposition within the polygon is expected, to a point of deposition in the next polygon downslope. Because the slope length is a landscape attribute, it is not affected by changes in land cover between polygons. The *L* value recorded for each polygon was the average horizontal distance measured perpendicular to the dominant direction of the contours, which is the dominant slope direction of the polygons. This horizontal distance measured on the map in planimetric view was assumed to approximate field slope length. The error in doing this, ranging from 0 to 10% depending on slope steepness, seemed to fall within the general crudeness of this method. The frequency of slope length measurements per polygon varied from a minimum of 3 to more than 20, depending on the polygon size and shape. Values for the topographic factor (*LS*) were obtained from the slope-effect chart (Fig. 3) and also recorded in each polygon on the soils maps. It is recognized that this crude method may result in overestimations of real field slope length.

Third, CLI land use maps for the area, revised in 1978 for the Select Standing Committee on Agriculture (1979), were fitted to the soil manuscript maps. Whenever a change in land use occurred within the soil polygon, the land use boundaries were transferred to the soil map, creating a new polygon for which the other factor values in the USLE remained the same. The minimum size of polygon allowed as a result of applying this process was held to about 1 cm^2, which represents about 100 ha on the ground.

Finally, unique polygon numbers were assigned for each map sheet and the USLE factor values for each polygon were entered into electronic data files (Lotus 1-2-3) for ease of data management.

An example of the data file structure is presented in Appendix 2. The average *R* factor of 34 was added to the files for each polygon. The value of 1 for the support practice factor (*P*) was not added to the computer files. A short program was written to calculate soil loss for each polygon by multiplying the recorded values for the USLE factors, to convert the results to metric units (t/ha), and to assign the soil loss values to one of six soil erosion classes. Data for polygon areas, measured by an electronic planimeter, were also added to the data base (Appendix 2). Table 4 summarizes the area, number of polygons, and average polygon size for each of the six map sheets and for the total map area.

Six water erosion prediction maps for the Peace River region of British Columbia were produced by transferring the polygon boundaries from the soil manuscript map to topographic base maps. The maps are included in the plastic pocket with the report.

WATER EROSION PREDICTION AND THEIR LIMITATIONS

The maps of water erosion prediction show the location and distribution of soil erosion in the B.C. Peace River region under the latest available land use conditions. The polygon symbol consists of two parts: a polygon number and the water erosion prediction class.

The polygon number, which is unique for each map sheet, provides a link to electronic data files. These files, organized by map sheet, contain for each polygon information for the factor values used in the USLE, the predicted average annual soil loss, the polygon area, and total soil loss. The latter is obtained by multiplying the average annual soil loss (t/ha) by the area to give total soil loss in tonnes for each polygon. An example of the computer file is presented in Appendix 2. Specific polygon information can be made available by the author to users upon request.

Six classes for erosion prediction are used on the map to indicate the relative susceptibility to average annual soil loss by water for each delineated area (polygon). Because of scale and data limitations, each class is expressed as a range in predicted soil loss values. In addition, because the average size of the polygons is large (520 ha for the six map sheets combined), large variations in soil loss caused by landscape and soil variability are likely within any polygon. The wide range in soil loss values for each erosion class also reflects this variability, as presented in Fig. 4. The soil loss data on the maps and in the report should be used as comparative, rather than absolute values.

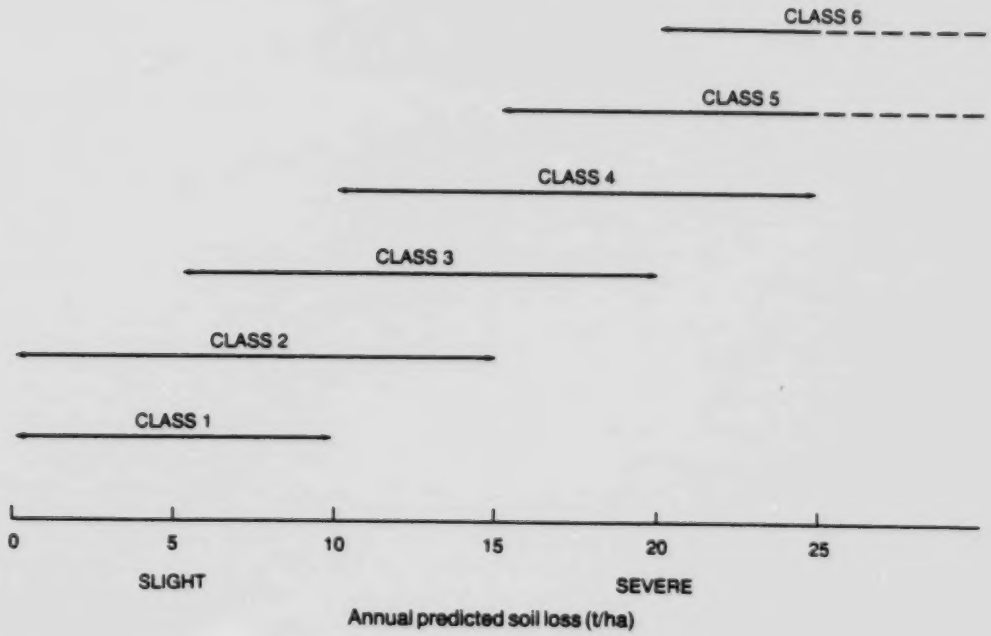

Fig. 4 Water erosion prediction classes showing expected range of soil loss.

Note that any change in land use or cropping practice may change the water erosion prediction class on the map. Soil losses in individual years may vary considerably from the long-term predicted average annual soil losses depicted on the maps, because of annual variations in rainfall intensity, duration, and snowmelt runoff.

APPLICATIONS

Two distinctly different major user groups are identified for erosion prediction maps: the primary producers (farmers, property owners) and regional planners. As the maps and the report are complementary, the use of both is recommended to understand fully the erosion predictions.

The first user group, when concerned about soil erosion, may want to know the relative soil loss on their farm or property, which they can obtain from the map. The predicted erosion class can be used as a guide to consider implementing soil conservation practices to reduce soil loss. For example, if the map indicates a field or property with an erosion prediction class of 3, which has an average annual predicted soil loss of between 5 and 20 t/ha, the following options are available for implementing soil conservation practices to reduce soil loss:

- conservation tillage of some type (e.g., reduced tillage, zero tillage, and spring tillage only);
- winter cover crops to protect the soil from snowmelt runoff in the winter and early spring, to be harvested or as plow down to build up the organic matter content in the surface soil;
- cross-slope farming or contour farming; and
- permanent grass cover and proper maintenance on all waterways and water runs.

More information on suggested soil conservation measures and erosion control practices to reduce soil loss can be found on the map legend and in a later section of the report. Data related to soil erosion (e.g., slope steepness, erodibility of the soil, average annual and total soil loss) is obtainable for the area (polygons) from the author upon request. For specific locations and small areas (<100 ha) within the polygon, soil losses are best estimated by on-site field inspection and soil sampling by a soil conservation specialist.

The second group likely to use erosion prediction information are planners. For example, they may use the maps in deciding whether or not to release Crown land for agricultural development, using the severity of predicted soil erosion as a criterion. Another example is as a guide to target any government funds for the reduction of soil erosion to areas with highest levels of erosion, or to the so called "hot spots" (e.g., erosion prediction classes 5 and 6). More applications become apparent in the discussion of assessment of magnitude and extent in the next section.

ASSESSMENT OF MAGNITUDE AND EXTENT

As mentioned in the previous section, each polygon has data on soil erosion factors associated with it in an electronic data file. Data summaries and cross tabulations were prepared using a computer software package (Lotus 1-2-3) for each map sheet separately and for the total study area. Values for soil erodibility (*K*), slope length (*L*), and slope gradient (*S*) were coded into six classes (Table 5) to simplify data handling and presentation.

Table 5 Class units for three variables in soil erosion data

Erosion class	*K*	*L*[1] (m)	*S* (%)
1 very low	0-0.10	0-300	0-2.5
2 low	0.11-0.20	301-600	3-5
3 medium	0.21-0.30	601-900	6-9
4 medium high	0.31-0.40	901-1200	10-15
5 high	0.41-0.50	1201-1500	16-30
6 very high	>0.50	>1500	>30

[1] Although *L* values are presented in metres, they were converted to feet for deriving *LS* values using the slope effect chart in Fig. 3.

AREAL DISTRIBUTION OF USLE FACTORS

Figs. 5, 6, 7, and 8 show the class values for percentage areal distribution of land use (*C*), soil erodibility (*K*), slope length (*L*), and slope steepness (*S*) by map sheet and for the B.C. Peace River region. For Fig. 5, only three of the four land use classes are presented because unproductive lands occupy a very small percentage of each map sheet area (0-2.2%). In Figs. 6, 7, and 8, the six classes for *K*, *L*, and *S* were combined into three classes to simplify data presentation. Full information on the areas of each of these four variables by map sheet is provided in Appendixes 3-6.

Land Use (*C* value)

From the areal distribution of land use data (Fig. 5), the Dawson Creek (93P/NE) and Fort St. John (94A/SE) map sheets stand out with the highest percentage of cropland, 35 and 44% respectively, representing the most developed agricultural areas in the Peace River region. The area north of the

Fort St. John map sheet (94A/NE) has 13% in cropland, whereas the area in cropland for the other map sheets is less than 10%. The total area in cropland in the Peace River region is represented by 18% of the map area. Area in permanent pasture represents the lowest percentage (5% or less) for each map sheet and for the total area, whereas the area in woodland accounts for the highest percentage land use category for each map sheet and for total area.

Note that the land use figures in this report are based on the latest available (1978) land use information. Undoubtedly, land use changes have taken place since that time, which are not reflected in the figures. Nevertheless, the relative area distribution or ranking of the different land use categories as presented in Fig. 5 are still valid, because they do not change rapidly over time.

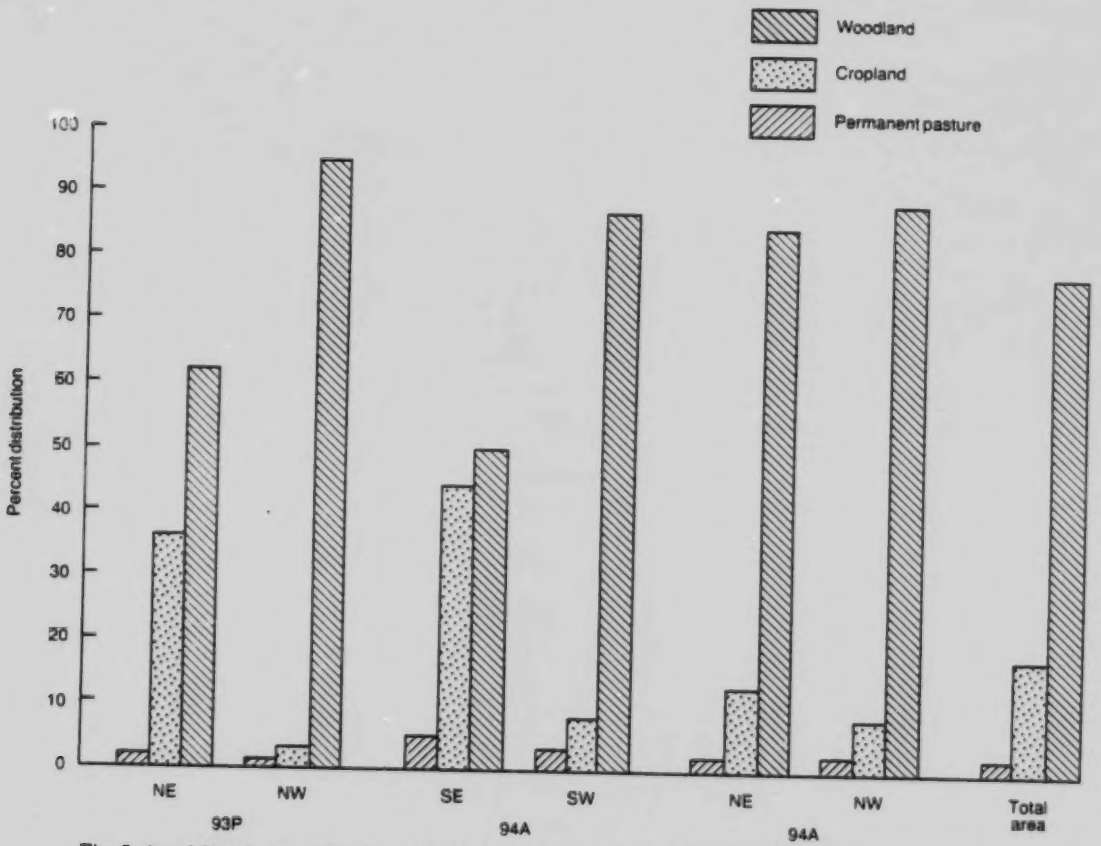

Fig. 5 Areal distribution of land use (*C* value) for each map sheet and for the B.C. Peace River region.

Soil erodibility (*K* value)

The areal distribution data of the soil erodibility factor (*K*) in Fig. 6 indicate that highly erodible soils having *K* values exceeding 0.40 (classes 5 and 6) occur most extensively (35%) in the Moberly Lake map area (sheet 93P/NW), followed by the Blueberry River (94A/NW), the Rose Prairie (94A/NE),

and the Fort St. John (94A/SE) map areas, covering 22, 18, and 16% of the map area, respectively. The remaining two map sheets have less than 10% of the area in highly erodible soils. For the total area, 18% of the soils are in the highly erodible group. Soils with medium erodibility, with *K* values between 0.21 and 0.40 (*K* value classes 3 and 4) make up the most extensive erodibility group (38-77%) on all map sheets and for the total area (60%), being highest for the Dawson Creek (93P/NE) and Blueberry River (94A/NW) map sheets, with 77 and 73% of the map area, respectively. When the high and medium erodibility groups are combined, the Blueberry River map sheet (94A/NW) has 95% of the area with *K* values greater than 0.20, followed by the Dawson Creek map sheet (93P/NE) with these *K* values on 85% of the area. For the total area of the Peace River region, 78% of the area is occupied by soils with *K* values greater than 0.20.

The relationship between *K* values and total soil loss is discussed later in the report.

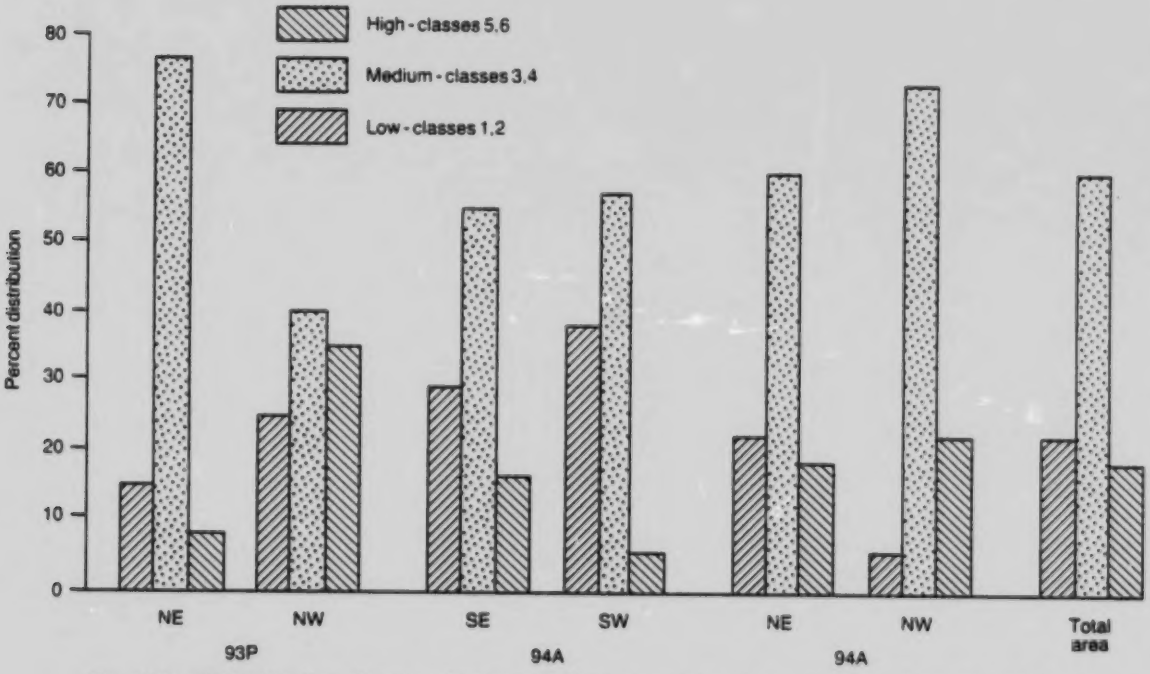

Fig. 6 Areal distribution of soil erodibility (*K* value) class for each map sheet and for the B.C. Peace River region.

Slope length (*L* value)

Areal distribution data for the slope length factor (*L*) (Fig. 7) show that for five out of the six map sheets, and for the total map area, slopes exceeding 1200 m (classes 5 and 6) are most extensive, varying between 42 and 73% of the map sheet and the total areas. Note that a slope of 1200 m long

represents a distance of only 12 mm on a 1:100 000 scale map. Because the average polygon size for the map area is 520 ha (Table 4) or 520 mm^2 on the map, it is not surprising that many polygons were measured with slopes exceeding 1200 m in length. Field verification produced evidence to suggest that the method of measuring slope length resulted in an overestimation of *L*. The relatively short slopes of less than 600 m (classes 1 and 2) occupy between 10 and 24% of each map sheet and 19% of the total map area, being the least extensive slope length category on all map sheets and for the total map area.

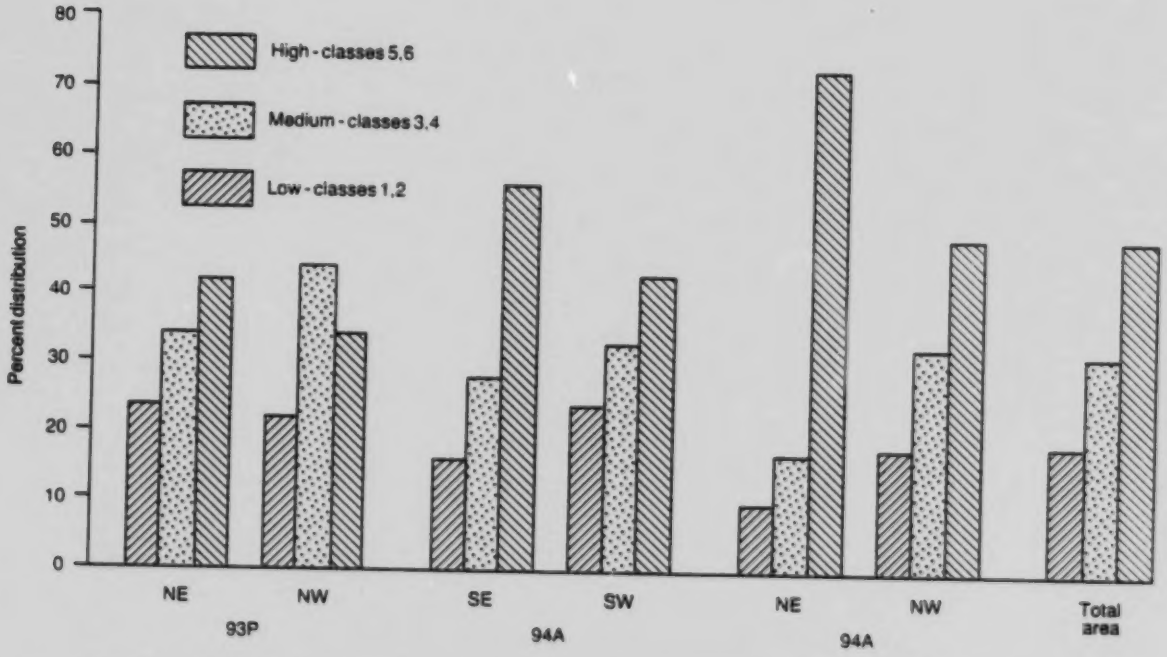

Fig. 7 Areal distribution of slope length (*L* value) class for each map sheet and for the B.C. Peace River region.

Slope steepness (*S* value)

The areal distribution data of slope steepness classes in Fig. 8 shows that gentle to moderately steep slopes varying between 6 and 15% (*S* value classes 3 and 4) are the most extensive; they occupy between 51 and 72% of the area on each map sheet, except Rose Prairie (94A/NE), and of the total map area (49%). Steeper slopes of more than 15% (*S* value classes 5 and 6) occur least extensively (between 5 and 18% of the area) on each map sheet, except Rose Prairie (94A/NE), and over the total area (16%). The Rose Prairie map sheet is characterized by 72% of the area having nearly level to very gentle slopes of less than 6%. Of all the map sheets, the Moberly Lake map sheet (93P/NW) represents the most extensive area (34%) of steep slopes (those exceeding 15%).

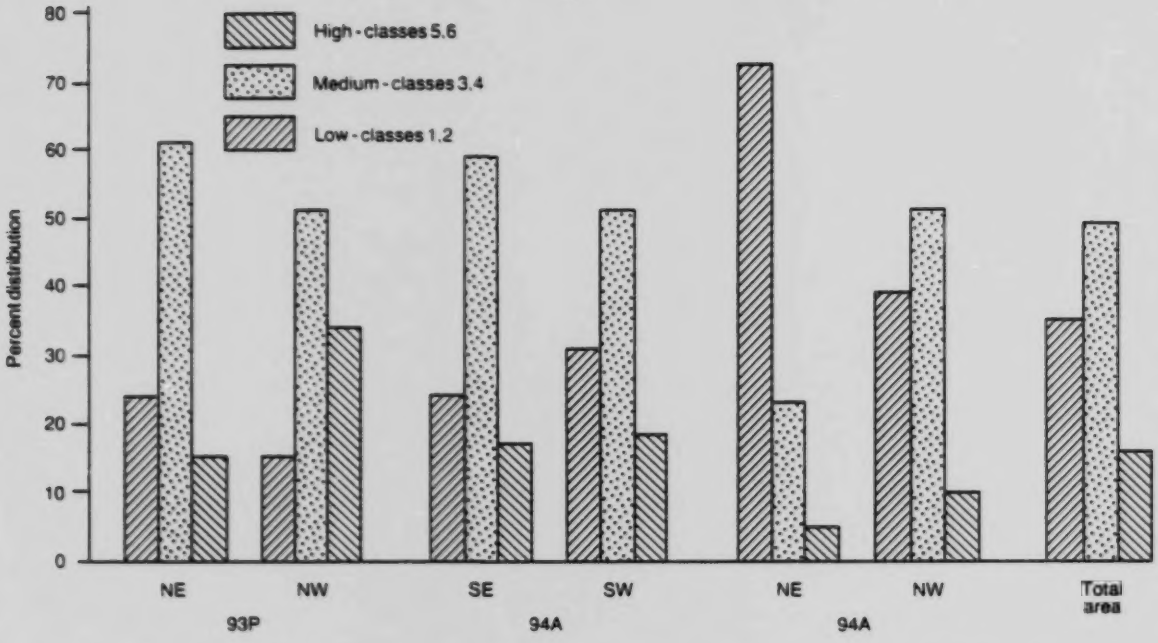

Fig. 8 Area distribution of slope steepness (*S* value) class for each map sheet and for the B.C. Peace River region.

DISTRIBUTION OF AREA, NUMBER OF POLYGONS, AND TOTAL ANNUAL PREDICTED SOIL LOSS*

The following three variables were analyzed and tabulated by erosion class and map sheet: area in hectares (Table 6), number of polygons (Table 7) and total annual predicted soil loss (Table 8). The areas represented by the map sheets are very similar, varying only 5.1% between the smallest (93P/NE) and largest (94A/NW) map sheet (336 682 to 353 740 ha), with a total map area of 2 068 260 (Table 6). With respect to number of polygons, two map sheets stand out as having the highest number of polygons: the Dawson Creek sheet (93P/NE) and Fort St. John sheet (94A/SE), accounting for 40% of the total number of polygons (Table 7). At the same time, both these map sheets have the highest total annual predicted soil loss, comprising 53.0% of the total annual predicted soil loss for the Peace River region (Table 8). The Dawson Creek and Fort. St. John map sheets represent the most developed agricultural areas in the region (Fig. 4). The frequency of land use changes within the soil-landscape polygons results first in the creation of many more polygons and, second, in higher total annual predicted soil loss because of a high *C* value of 0.30 for cropland.

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* Total or gross annual soil loss is the predicted soil loss in tonnes per hectare multiplied by the polygon area in hectares. For example, in Appendix 2, total soil loss (last column) = column 8 (*A* in t/ha/year) multiplied by column 10 (area in ha).

Table 6. Area by erosion class and for each map sheet and for the B.C. Peace River region

Erosion class	Map sheet (ha)						Total area	
	93P/NE	93P/NW	94A/SE	94A/SW	94A/NE	94A/NW	(ha)	(%)
1	228 788	268 346	198 731	313 171	306 990	312 720	1 628 746	78.8
2	40 112	66 328	42 260	13 910	15 330	28 470	206 408	10.0
3	39 884	7 650	49 130	5 810	9 930	4 030	116 434	5.6
4	17 101	4 310	31 250	4 337	12 100	4 700	73 798	3.6
5	5 794	140	9 470	1 702	1 330	310	18 746	0.9
6	5 003	960	7 050	4 685	2 920	3 510	24 128	1.1
Total	336 682	347 732	337 891	343 615	348 600	353 740	2 068 260	100

The percent distribution of the area by erosion class (last column of Table 6) is similar to the distribution of the number of polygons (last column of Table 7). In both cases, lowest predicted soil losses (classes 1 and 2) occurred on the highest percentage (>85%) of both total area and total number of polygons, whereas only 2% of the total area (Table 6) and 3.4% of the total number of polygons (Table 7) are in the highest soil loss category (erosion classes 5 and 6). When comparing these percentages with the distribution of the total or gross annual soil loss in Table 8, note that for erosion classes 1 and 2 combined, 46.7% of the total annual predicted soil loss occurs on 88.8% of the total area (Table 6) whereas for erosion classes 5 and 6, 17.8% of the total predicted annual soil loss is produced on 2.0% of the total area.

Table 7 Number of polygons by erosion class for each map sheet and for the B.C. Peace River region

Erosion class	Map sheet						Total number	(%)
	93P/NE	93P/NW	94A/SE	94A/SW	94A/NE	94A/NW		
1	496	526	496	539	447	396	2900	72.9
2	119	120	101	54	49	41	484	12.2
3	83	30	94	23	18	15	263	6.6
4	49	13	70	13	35	16	196	4.9
5	16	2	26	8	3	2	57	1.4
6	18	5	16	17	5	18	79	2.0
Total	781	696	803	654	557	488	3979	100.0

These results could serve as guidelines for the development of erosion control strategies for the region. For example, among the six map sheets, clearly one should concentrate on the Dawson Creek and Fort St. John map areas, and on the high erosion classes (5 and 6) of any map area.

Thus, if one were to consider instituting erosion control measures for the region, the best results would be achieved by targeting erosion control to the high erosion category (classes 5 and 6), for which 1% of the total land area affects 8.9% of the total predicted soil loss (17.8% of total soil loss divided by 2% of the total area). By comparison the low erosion category (classes 1 and 2), for which 1% of the total land area affects only 0.5% of the total predicted soil loss (46.7% of total soil loss divided by 88.8% of total area), would not yield such dramatic results for a similar effort expended.

Table 8 Distribution of total annual predicted soil loss by erosion class and map sheet

EROSION CLASS (%)					
1	2	3	4	5	6
26.9	19.8	19.1	16.3	5.5	12.3
MAP SHEET (%)					
93P/NE	93P/NW	94A/SE	94A/SW	94A/NE	94A/NW
23.3	14.2	29.7	11.2	10.3	11.2

DISTRIBUTION OF TOTAL ANNUAL PREDICTED SOIL LOSS BY LAND USE AND SOIL ERODIBILITY

Fig. 9 shows the distribution of total annual predicted or annual gross soil loss by land use (*C* value) class for the entire area based on soil loss prediction data by erosion class (Table 8) and land use category (Appendix 7). About two-thirds of the total soil loss in the entire study area occurs on cropland, whereas about one-third of the total soil loss is produced on woodland. Intuitively, one would expect a much lower percentage of total soil loss from woodlands. However, as has been shown before (Fig. 5), 78.4% of the total map area is woodland. Even low unit area soil losses (t/ha) contribute significantly to the total annual soil loss picture when they occur over large areas. In addition, most steeper slopes are found in woodlands, contributing to relatively higher soil losses than if slopes were less steep. Total annual predicted soil loss for woodland becomes progressively less for increasing

soil erosion prediction classes (from 1 to 4), with no soil loss for erosion prediction classes 5 and 6.

In terms of erosion control, efforts to reduce total annual soil loss in the B.C. Peace River region, focus naturally on the cropland category, particularly as only 18% of the total area is in cropland (Fig. 5) yet produces 64% of the total soil loss for the region (Fig. 9).

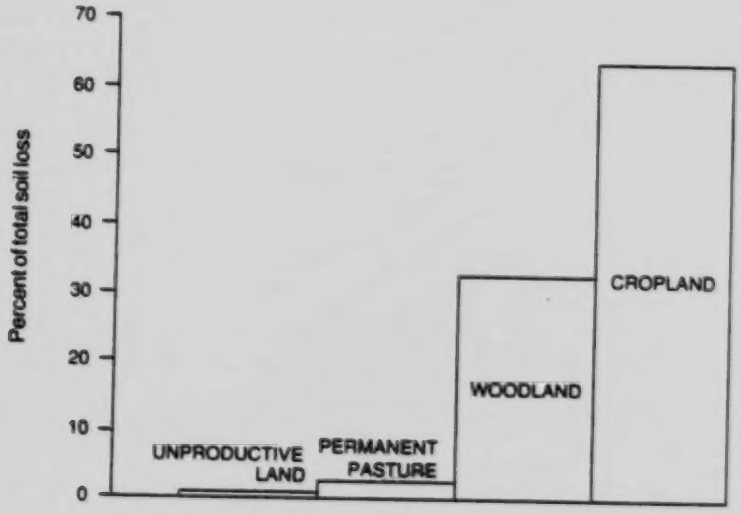

Fig. 9 Distribution of total predicted soil loss by land use for the B.C. Peace River region.

Based on Appendix 7 and on area data by erosion class and land use category (Appendix 8), a more detailed breakdown of the cropland category is given in Fig. 10, which shows the total annual cropland soil loss in relation to the area in cropland, in cumulative percentages, for each erosion class. A curve connects the erosion prediction classes, as the prediction classes are not discrete, but form a continuum (Fig. 4). The curve in Fig. 10 indicates that for the high erosion categories (classes 4-6 on the curve), 10% of the cropland area (e.g., from 90 to 100% cumulative area) produces 26% of the total annual cropland soil loss, whereas, for the lowest erosion category (classes 1-3), 10% of the cropland area produces only 8% of the total annual cropland soil loss. This relationship shows clearly that for remedial measures or soil conservation practices with the purpose of reducing annual soil loss on cropland to be most effective, efforts should focus on the higher erosion prediction classes (4-6) compared with the lower erosion prediction classes (1-3). The water erosion prediction maps accompanying this report are a useful tool for planning soil conservation.

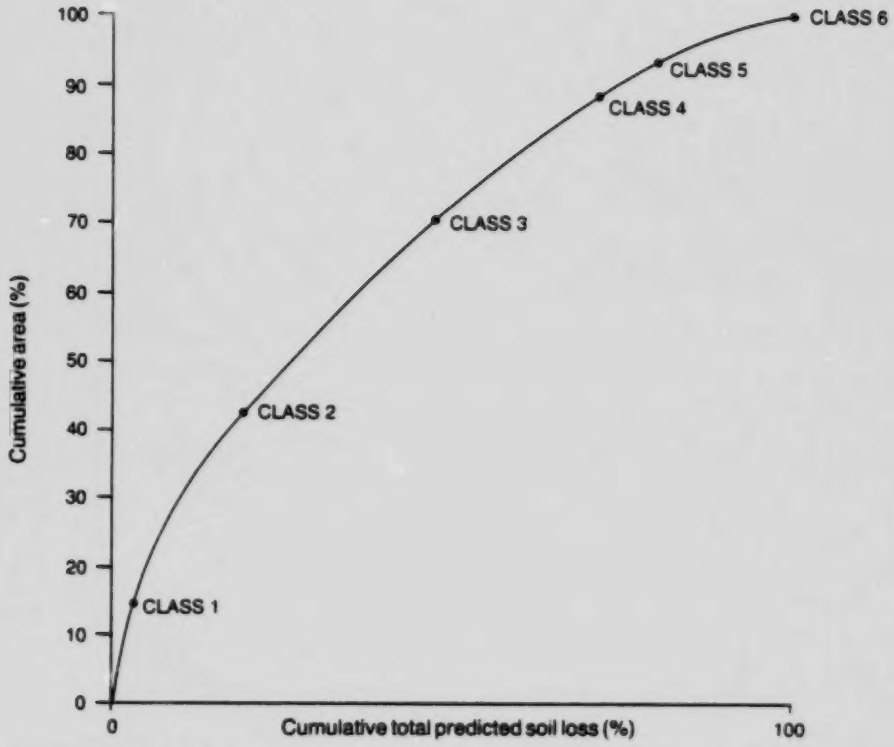

Fig. 10 Relationship between area in cropland and cropland soil loss for erosion prediction classes.

Fig. 11 shows the distribution of total annual predicted soil loss by soil erodibility (*K* value) class for the B.C. Peace River region, based on

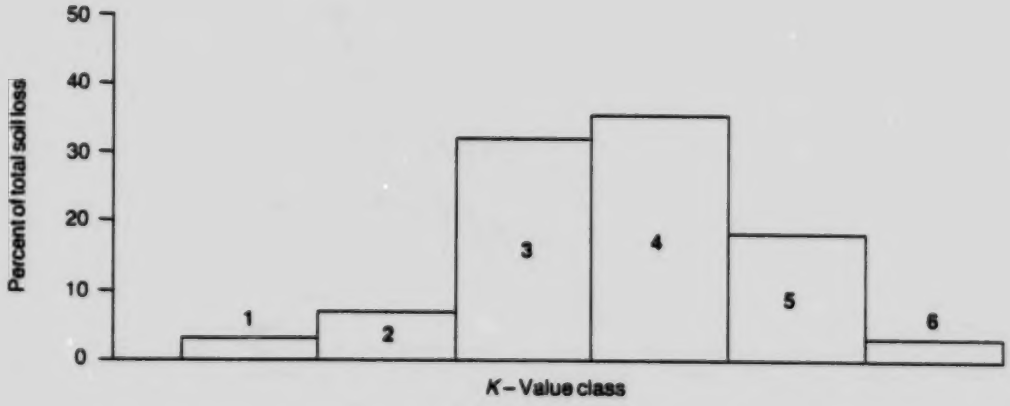

Fig. 11 Distribution of total annual predicted soil loss by *K*-value class for the B.C. Peace River region.

predicted soil loss data by erosion class (Table 8) and *K*-value class (Appendix 9). In terms of soil erodibility, the medium erodible soils with *K* values between 0.21 and 0.40 (*K*-value classes 3 and 4) account for 66% of the total annual predicted soil loss for the B.C. Peace River region, and 22% of the total annual predicted soil loss comes from highly erodible soils that have *K* values greater than 0.40 (*K*-value classes 5 and 6). Highly erodible soils are characterized by the following:

- silt and very fine sand content greater than 60%
- a relatively low organic matter content of 2% or less
- surface soil structure other than granular
- slowly permeable subsoils.

Although the absolute soil loss figures may change as more information becomes available and after final modifications to the USLE have been made, the relative soil loss figures and comparisons on a regional basis remain valid.

CONSERVATION MEASURES FOR CONTROLLING SOIL EROSION

Whenever sloping soil is to be cultivated and exposed to erosive rains and runoff, protection offered by the cropping system needs to be supported by practices that will slow the runoff and thus reduce the amount of soil that the water can carry. The most important of these supporting cropland practices are contour tillage and planting and strip cropping.

Tillage and planting across, rather than with, the slope can reduce soil loss by 25%. Where practical, tillage and planting on the contour of the soil landscape can reduce soil loss by 50%. These practices appear to be most effective on slopes in the 3-8% range (Wischmeier and Smith 1978), by increasing the infiltration of runoff into the soil. Tillage diagonal to the slope, which is now practiced in the Peace River region, is less effective than tillage on the contour, i.e., across the slope.

Strip cropping is an erosion control measure that can be used on long, smooth slopes. Soil losses can be reduced by 60% by strip cropping across the slope rather than up-down slope cropping. Contour strip cropping reduces soil loss even more. Alternate strips of summer fallow and crop, or an annually cultivated crop and perennial grass, can be used. Strip cropping, to be most effective, dictates the use of a sod-based crop (perennial grass crop). As slope steepness increases, the strip width should decrease. Strip crop studies have shown that much of the soil eroded from a cultivated strip was filtered out of the runoff as it slowed down and was spread within the first several metres of the adjacent sod strip (Wischmeier and Smith 1978).

These supporting cropland practices, including terracing, can be accounted for in the USLE by means of the erosion control or support practice factor (*P*) discussed earlier.

Seven other soil conservation practices for controlling soil erosion by water are as follows:

(1) Conservation tillage, which reduces the number of tillage operations and uses tillage implements that leave significant amounts of crop residue and stubble at the surface for erosion protection, reduces soil loss. Reduced tillage and zero-tillage are forms of conservation tillage.

(2) Reduction of the area in summer fallow reduces soil loss; measurements on erosion plots indicated conclusively that summer-fallowing produced greater soil loss than any other land use (van Vliet et al. 1986).

(3) Elimination of tillage in the fall leaves the stubble intact after harvest, and protects the soil from snowmelt runoff.

(4) Winter cover crops, such as winter wheat, winter rye, and winter canola, also protect the soil from erosion and can be used as plow-down (green manure) to enrich the soil by increasing the organic matter content.

(5) Crop rotations that include sod-based crops (e.g., forage crops and perennial grasses) rather than continuous cropping help to reduce soil loss.

(6) Preparation and maintenance of natural surface drainageways through cultivated fields; the waterway should be seeded to a permanent grass cover and properly maintained by keeping the grass short so as to maintain its effectiveness.

(7) Retirement into permanent pasture or woodland of low productive fields with slopes steeper than 15% on which severe erosion has occurred and from which much topsoil has already been lost.

The suitability of any of these soil conservation measures for controlling erosion by water has to be evaluated for each individual situation. With increased awareness of the need for soil conservation practices in the Peace River region, more experience can be gained and made available on the effectiveness and adoption of these practices to local circumstances.

CONCLUSIONS

Based on the results of this study, six conslusions are drawn as follows:

(1) Application of the USLE to soil map polygons is a useful method by which to estimate relative levels of average annual soil losses to be expected under conditions found in the Peace River region of British Columbia.

(2) About two-thirds of total annual predicted soil loss in the entire study area occurs on cropland, occupying only 18% of the B.C. Peace River region.

(3) The most developed agricultural areas in the Peace River region, namely Dawson Creek (93P/NE) and Fort St. John (94A/NE) map sheets with 79% of the total cropland area, experience 53% of the total predicted soil loss for the region.

(4) In determining erosion control strategies for the region, the soil loss results will help in targeting effective and efficient erosion control programs. For example, programs should be concentrated on the Dawson Creek and Fort St. John map sheets, on the high erosion classes (5 and 6), and on the cropland category of each map sheet.

(5) Information on the maps and in the report will help primary producers to select appropriate measures for soil conservation to be applied to areas categorized in erosion prediction classes 3-6 and thus to reduce soil erosion by water.

(6) A better method for determining slope length and more up-to-date land use and crop cover information will improve predictions of soil loss for this region, without invalidating the relative comparisons presented in this report.

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Appendix 1. Soil erodibility factor (*K*) values for B.C. Peace River soils

Soil name	Surface texture	*K* value
Alright	loam	0.20
Alright	silt loam	0.31
Alcan	loam	0.31
Alcan	silt loam	0.46
Alces	sandy loam	0.17
Arras	silty clay loam	0.28
Attachie (Septimus)	colluvium	-
Bear Flats	fine sandy loam	0.13
Beatton	silty clay loam	0.35
Beryl	fine sandy loam	0.20
Boundary	silt loam	0.29
Boundary	silty clay loam	0.36
Branham	silt loam	0.41
Buick	loam	0.36
Bullmoose (Zonnebecke)	loam	0.35
Bulley (Lean-to)	loam	0.23
Centurion	loam	0.28
Centurion	loam	0.22
Chowade (Horseshoe)	loam	0.32
Clayhurst	sandy clay loam	0.28
Codesa	silt loam	0.36
Codner	silt loamy loam	0.31
Cogol	organic soil	-
Coldstream	silt loam	0.31
Coleman	silt loam	0.26
Coleman	fine sandy loam	0.40
Davis	very fine sandy loam	0.35
Demmitt	sandy loam	0.27
Demmitt	silt loam	0.57
Devereau	silty clay loam	0.27
Doig	silty clay loam	0.29
Donnelly	fine sandy loam	0.24
Donnelly	silt loam	0.44
Eaglesham	organic soil	-
Esher	loam	0.17
Esher	clay loam	0.18
Esher	silty clay loam	0.25
Falher	clay loam	0.22
Falher	silty clay loam	0.23
Farrell	silt loam	0.39
Fellers	silt loam	0.36
Goose	silty clay loam	0.25
Groundbirch	loamy sand	0.08
Hanshaw	sandy clay loam	0.18
Hazelmere	silt loam	0.50
Horseshoe (Chowade)	loam	0.32
Jedney	silt loam	0.38
Jedney	very fine sandy loam	0.59
Judah	silty clay loam	0.23
Kathleen	silty clay loam	0.27
Kenzie	organic soil	-
LaPrise	silty clay loam	0.29
Landry	clay loam	0.14
Landry	silt loam	0.27
Lean-to	loam	0.23
Lynx	fine sandy loam	0.22
Lynx	silt loam	0.36
Lynx	silt loam	0.59
Milligan	clay loam	0.29
Moberly	silt loam	0.42
Moberly	silt loam	0.60
Murdale	loam	0.25
Murdale	silty clay loam	0.24
Mytron	sandy loam	0.09
Mytron	clay loam	0.23
Mytron	silty clay loam	0.31
Nampa	clay loam	0.33
Nampa	silt loam	0.42
Neumann	gravelly loam	0.32
Oetca	loam	0.13
Peoria	loam	0.24
Pingel	clay	0.15
Portage Creek (Twidwell)	gravelly sandy loam	0.15
Prespatou	silty clay loam	0.31
Rolla	silty clay loam	0.26
Roseland	clay	0.14
Roseland	clay	0.15
Rycroft	silty clay loam	0.25
Shearerdale	sandy loam	0.16
Sloane	fine sandy loam	0.15
Snipe	loam	0.27
Snipe	silt loam	0.59
Snipe	silty clay	0.27
Sundance	loamy sand	0.06
Sundance	loamy sand	0.12
Sundance	sandy loam	0.29
Sukunka	silt loam	0.41
Taylor	silty clay loam	0.22
Toad	silt loam	0.62
Tremblay Creek	fine sandy loam	0.13
Twidwell (Portage Creek)	gravelly sandy loam	0.15
Widmark	silt loam	0.43
Wonowon	silty clay loam	0.30
Zonnebecke (Bullmoose)	loam	0.35

Appendix 2. Sample printout of data file; USLE values for 93P/NE

Polygon	K	L	S	LS	C	R	A	Class	Area (ha)	Soil loss (t/year)
1	0.42	940	9	1.40	0.02	34	0.9	1	293	264
2	0.49	563	20	7.50	0.02	34	5.6	2	260	1456
3	0.49	563	20	7.50	0.02	34	5.6	2	1230	6888
4	0.49	563	20	7.50	0.02	34	5.6	2	660	3696
5	0.40	600	6	1.50	0.02	34	0.9	1	960	864
6	0.40	600	6	1.50	0.02	34	0.9	1	140	126
7	0.42	640	6	1.50	0.02	34	1.0	1	140	140
8	0.42	640	6	1.50	0.05	34	2.4	1	70	168
9	0.33	1650	6	2.00	0.02	34	1.0	1	90	90
10	0.42	640	6	1.50	0.02	34	1.0	1	40	40
11	0.33	1650	6	2.00	0.30	34	15.1	4	300	4530
12	0.33	1650	6	2.00	0.30	34	15.1	4	380	5738
13	0.33	6390	6	2.00	0.30	34	15.1	4	300	4530
14	0.33	6390	6	2.00	0.05	34	2.5	1	60	150
15	0.33	6390	6	2.00	0.05	34	2.5	1	60	150
16	0.40	1048	6	1.80	0.30	34	16.5	4	110	1815
17	0.40	1048	6	1.80	0.02	34	1.1	1	190	209
18	0.40	1048	6	1.80	0.02	34	1.1	1	100	110
19	0.40	1048	6	1.80	0.02	34	1.1	1	200	220
20	0.40	1048	6	1.80	0.02	34	1.1	1	200	220
21	0.28	1389	6	1.90	0.02	34	0.8	1	100	80
22	0.28	1389	6	1.90	0.30	34	12.2	3	40	488
23	0.40	2615	6	2.00	0.05	34	3.0	1	120	360
24	0.40	2615	4	1.20	0.02	34	0.7	1	1660	1162
25	0.40	2615	4	1.20	0.30	34	11.0	3	343	3773
26	0.26	300	6	1.30	0.30	34	7.7	2	90	693
27	0.35	1100	4	1.10	0.30	34	8.8	2	77	678
28	0.35	1100	4	1.10	0.30	34	8.8	2	174	1531
29	0.35	1100	4	1.10	0.02	34	0.6	1	1383	830
30	0.35	1100	4	1.10	0.02	34	0.6	1	60	36
31	0.07	730	52	28.00	0.02	34	2.1	1	677	1422
32	0.25	860	3	0.75	0.05	34	0.7	1	147	103
33	0.25	860	3	0.75	0.02	34	0.3	1	353	106
34	0.25	860	3	0.75	0.30	34	4.3	1	667	2868
35	0.19	370	10	2.70	0.02	34	0.8	1	227	182
36	0.19	917	4	1.10	0.02	34	0.3	1	307	92
37	0.19	917	4	1.10	0.30	34	4.8	1	374	1795
38	0.34	1650	6	2.00	0.30	34	15.5	4	1313	20352
39	0.34	1650	6	2.00	0.02	34	1.0	1	773	773
40	0.25	1400	6	2.00	0.30	34	11.4	3	194	2212
41	0.36	525	4	1.00	0.30	34	8.2	2	253	2075
42	0.33	1250	3	0.86	0.30	34	6.5	2	45	293
43	0.05	290	1	0.25	0.02	34	0.0	1	90	0
44	0.33	1250	3	0.86	0.02	34	0.4	1	130	52
45	0.33	1250	3	0.86	0.30	34	6.5	2	177	1151
46	0.34	2000	6	2.00	0.30	34	15.5	4	650	10075
47	0.34	2000	6	2.00	0.02	34	1.0	1	80	80
48	0.34	2000	6	2.00	0.02	34	1.0	1	475	475
49	0.13	1077	3	0.80	0.30	34	2.4	1	157	377
50	0.13	1077	3	0.80	0.02	34	0.2	1	170	34

Appendix 3. Area by land use (C value) for each map sheet and for B.C. Peace River region

Land use	Map sheet area (ha)						Total area	
	93P/NE	93P/NW	94A/SE	94A/SW	94A/NE	94A/NW	(ha)	(%)
Woodland	208 675	331 235	170 141	299 893	297 050	315 580	1 622 574	78.4
Unproductive land	210	2 155	3 500	7 674	140	0	13 679	0.7
Permanent pasture	7 232	4 507	17 130	9 657	6 900	8 360	53 786	2.6
Cropland	120 565	9 835	147 120	26 391	44 510	29 800	378 221	18.3
Total	336 682	347 732	337 891	343 615	348 600	353 740	2 068 260	100.0

Appendix 4. Area by soil erodibility (K value) class for each map sheet and for B.C. Peace River region

K-value class	Map sheet area (ha)						Total area	
	93P/NE	93P/NW	94A/SE	94A/SW	94A/NE	94A/NW	(ha)	(%)
1	13 352	43 313	59 470	64 706	20 460	2 630	203 931	9.8
2	36 637	44 715	39 310	66 053	56 840	15 000	258 555	12.5
3	155 769	72 022	93 590	84 646	88 710	57 260	551 997	26.7
4	103 420	67 638	91 160	110 239	118 820	199 880	691 157	33.4
5	24 810	95 804	47 031	14 437	53 100	72 100	307 282	14.9
6	2 694	24 240	7 330	3 534	10 670	6 870	55 338	2.7
Total	336 682	347 732	337 891	343 615	348 600	353 740	2 068 260	100.0

Appendix 5. Area by slope length (*L* value) class for each map sheet and for B.C. Peace River region

L-value class	Map sheet area (ha)						Total area	
	93P/NE	93P/NW	94A/SE	94A/SW	94A/NE	94A/NW	(ha)	(%)
1	15 348	6 700	6 170	12 359	8 160	9 520	58 257	2.8
2	64 321	69 549	48 650	69 786	25 110	56 210	333 626	16.1
3	65 814	96 660	47 290	64 963	2 970	57 020	359 717	17.4
4	50 088	56 640	45 710	48 066	32 980	58 830	292 314	14.1
5	54 221	44 040	44 590	31 157	20 210	53 280	247 498	12.0
6	86 890	74 143	145 481	117 284	234 170	118 880	776 848	37.6
Total	336 682	347 732	337 891	343 615	348 600	353 740	2 068 260	100.0

Appendix 6. Area by slope steepness (*S* value) class for each map sheet and for B.C. Peace River region

S-value class	Map sheet area (ha)						Total area	
	93P/NE	93P/NW	94A/SE	94A/SW	94A/NE	94A/NW	(ha)	(%)
1	7 296	11 985	10 680	18 438	155 820	31 590	235 809	11.4
2	73 291	40 958	71 321	87 302	96 650	106 750	476 272	23.0
3	161 231	120 824	158 990	134 079	61 110	111 740	747 974	36.2
4	43 274	57 248	40 430	43 216	17 260	69 880	271 308	13.1
5	38 992	59 246	8 140	9 631	14 780	16 500	147 289	7.1
6	12 598	57 471	48 330	50 949	1 980	17 280	189 608	9.2
Total	336 682	347 732	337 891	343 615	348 600	353 740	2 068 260	100.0

Appendix 7. Distribution of total annual predicted soil loss by land use category

Woodland (%)	Unproductive land (%)	Permanent pasture (%)	Cropland (%)
33.5	0.2	2.6	63.8

Appendix 8. Area by erosion class for each land use category and for B.C. Peace River region

Erosion class	Woodland (ha)	Unproductive land (ha)	Permanent pasture (ha)	Cropland (ha)	Region (ha)	Region (%)
1	1 522 835	13 679	38 588	53 644	1 628 746	78.7
2	88 456	0	13 429	104 523	206 408	10.0
3	7 663	0	233	108 538	116 434	5.6
4	3 460	0	1 433	68 905	73 798	3.6
5	160	0	103	18 483	18 746	0.9
6	0	0	0	24 120	24 128	1.2
Total	1 622 574 78.4%	13 679 0.7%	53 786 2.6%	378 221 18.3%	2 068 260	100.0

Appendix 9. Distribution of total annual predicted soil loss by *K*-value class

K-value class (%)					
1	2	3	4	5	6
3.4	6.9	32.1	35.5	18.4	3.6

MAPS
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CARTES
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